PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-035777
(43)Date of publication of application : 09.02.2001

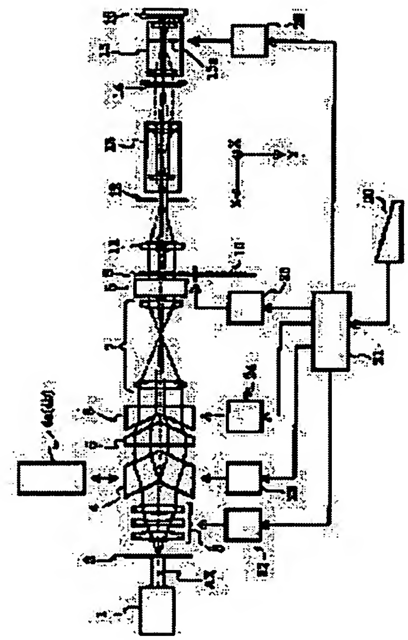
(51)Int.Cl. H01L 21/027
G03F 7/20

(21)Application number : 11-208374
(22)Date of filing : 23.07.1999

(71)Applicant : NIKON CORP
(72)Inventor : SHIBUYA MASATO
TANITSU OSAMU

(54) ILLUMINATION OPTICAL APPARATUS AND ALIGNER HAVING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain an illumination optical apparatus which can provide irregular illumination, such as annular illumination or four-pole illumination, while properly suppressing light quantity loss at an aperture stop.
SOLUTION: This apparatus includes a focal-length variable optical system 3 for similarly changing the shape of a flux of light from a light source 1 or 2 by changing its focal length and emitting it, and a light-flux shape changing member 4 for converting the shape of light flux from the focal-length variable optical system 3 into a ring-band shape or into a plurality of light fluxes, biased with respect to a reference optical axis AX and guiding it to an optical integrator 8.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] A light source means for supplying the flux of light Capacitor optical system for condensing the flux of light from the secondary light source formed by an optical integrator and this optical integrator for forming the secondary light source which consists of much light sources based on the flux of light from this light source means, and illuminating an irradiated plane in superposition Focal distance adjustable optical system for changing a configuration of the flux of light from said light source means in similarity, and injecting it by being illumination-light study equipment equipped with the above, and changing a focal distance, It is characterized by having a flux of light configuration modification member for changing into two or more flux of lights which carried out eccentricity of the flux of light from this focal distance adjustable optical system to zona-orbicularis-like the flux of light or a criteria optical axis substantially, and leading to said optical integrator.
[Claim 2] Said flux of light configuration modification member has the 1st prism member constituted free [insertion and detachment] to an illumination-light way. It is illumination-light study equipment according to claim 1 characterized by forming a field by the side of a light source means of said 1st prism member the shape of the shape of a cone, and a pyramid which turned a concave surface to a light source means side, and forming a field by the side of an irradiated plane of said 1st prism member the shape of the shape of a cone, and a pyramid which turned a convex to an irradiated plane side.
[Claim 3] Illumination-light study equipment according to claim 1 or 2 characterized by having a zona-orbicularis ratio modification member for changing a bore and an outer diameter of the flux of light of the shape of zona orbicularis formed through said flux of light configuration modification member, or two or more flux of lights which carried out eccentricity, and leading to said optical integrator.
[Claim 4] Have the following and a field by the side of an irradiated plane of said 2nd prism member is formed in the shape of [which turned a convex to an irradiated plane side] a cone. A field by the side of a light source means of said 3rd prism member is formed in the shape of [which turned a concave surface to a light source means side] a cone. Either [at least] said 2nd prism member or said 3rd prism members Illumination-light study equipment according to claim 3 characterized by being constituted movable in accordance with said criteria optical axis. Said zona-orbicularis ratio modification member is the 2nd prism member arranged at a light source means side. The 3rd prism member arranged at an irradiated plane side
[Claim 5] Said light source means is illumination-light study equipment given in claim 1 characterized by having a flux of light sensing element for changing the flux of light from the light source and this light source for supplying the rectangle-like flux of light into the flux of light of a circle configuration thru/or any 1 term of 4.
[Claim 6] An aligner characterized by having illumination-light study equipment given in claim 1 thru/or any 1 term of 5, and projection optics for carrying out projection exposure of the pattern of a mask arranged on said irradiated plane at a photosensitive substrate.
[Claim 7] An exposure method characterized by illuminating a mask arranged on said irradiated plane using illumination-light study equipment given in claim 1 thru/or any 1 term of 5, and imprinting a pattern of this mask on a photosensitive substrate.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the suitable illumination-light study equipment for the aligner for especially manufacturing a semiconductor device etc. at a lithography production process about the aligner equipped with illumination-light study equipment and this illumination-light study equipment.
[0002]
[Description of the Prior Art] In this kind of aligner, incidence of the flux of light injected from the light source is carried out to a fly eye lens, and it forms in an after that side focal plane the secondary light source which consists of many light source images. After the flux of light from the secondary light source is restricted through the aperture diaphragm arranged near the backside [a fly eye lens] focal plane, incidence of it is carried out to a condenser lens. An aperture diaphragm restricts to the configuration of the secondary light source, the configuration of a request of magnitude, or magnitude according to desired lighting conditions (exposure conditions).
[0003] The flux of light condensed by the condenser lens illuminates in superposition the mask with which the predetermined pattern was formed. Image formation of the light which penetrated the pattern of a mask is carried out on a wafer through projection optics. In this way, on a wafer, projection exposure (imprint) of the mask pattern is carried out. In addition, it is indispensable to integrate highly the pattern formed in the mask and to imprint this detailed pattern correctly on a wafer to acquire uniform illumination distribution on a wafer.
[0004] In recent years, the technology of changing the magnitude of the secondary light source formed of a fly eye lens, and changing the coherency mho of lighting (sigma value = **** of the diameter of an aperture diaphragm / projection optics or incidence side numerical aperture of the injection side numerical aperture / projection optics of a sigma value = illumination-light study system) attracts attention by changing the magnitude of opening of the aperture diaphragm arranged at the injection side of a fly eye lens. Moreover, by setting up the configuration of opening of the aperture diaphragm arranged at the injection side of a fly eye lens the shape of zona orbicularis, and in the shape of 4 holes (the shape of namely, 4 poles), the configuration of the secondary light source formed of a fly eye lens is restricted the shape of zona orbicularis, and in the shape of 4 poles, and the technology of raising the depth of focus and resolution of projection optics attracts attention.
[0005]
[Problem(s) to be Solved by the Invention] As mentioned above, with the conventional technology, in order to restrict the configuration of the secondary light source the shape of zona orbicularis, and in the shape of 4 poles and to perform deformation lighting (zona-orbicularis deformation lighting and 4 pole deformation lighting), the aperture diaphragm which has opening of the shape of the shape of zona orbicularis or 4 poles has restricted the flux of light from the comparatively big secondary light source formed in the shape of a rectangle of the fly eye lens. If it puts in another way, with the zona-orbicularis deformation lighting or 4 pole deformation lighting in the conventional technology, the considerable portion of the flux of light from the secondary light source will be covered by the aperture diaphragm, and will not contribute to lighting (exposure). Consequently, there was un-arranging [that the illuminance on a mask and a wafer fell and the throughput as an aligner also fell by quantity of light loss in an aperture diaphragm].
[0006] This invention is made in view of the above-mentioned technical problem, and it aims at offering the aligner equipped with the illumination-light study equipment and this illumination-light study equipment which can perform deformation lighting like zona-orbicularis lighting or 4 pole lighting, suppressing the quantity of light loss in an aperture diaphragm good.
[0007]
[Means for Solving the Problem] In order to solve said technical problem, in the 1st invention of this invention An optical integrator for forming the secondary light source which consists of much light sources based on the flux of light from a light source means and this light source means for supplying the flux of light, In illumination-light study equipment equipped with capacitor optical system for condensing the flux of light from the secondary light source formed by this optical integrator, and illuminating an irradiated plane in superposition Focal distance adjustable optical system for changing a configuration of the flux of light from said light source means in similarity, and injecting it by changing a focal distance, Illumination-light study equipment characterized by having a flux of light configuration modification member for changing into two or more flux of lights which carried out eccentricity of the flux of light from this focal distance adjustable optical system to zona-orbicularis-like the flux of light or a criteria optical axis substantially, and leading to said optical integrator is offered.
[0008] According to the desirable mode of the 1st invention, said flux of light configuration modification member has the 1st prism member, a field by the side of a light source means of said 1st prism member is formed the shape of the shape of a cone, and a pyramid which turned a concave surface to a light source means side, and, as for a field by the side of an irradiated plane of said 1st prism member, it is desirable to be formed the shape of the shape of a cone and a pyramid which turned a convex to an irradiated plane side. In this case, as for said flux of light configuration modification member, it is desirable to be constituted free [insertion and detachment] to an illumination-light way. Moreover, it is desirable to constitute a field by the side of a light source means of said 1st prism member and a field by the side of an irradiated plane in parallel so that it may be maintained, when an inclination to said criteria optical axis of light which carries out incidence to said flux of light configuration modification member in this case injects from said flux of light configuration modification member.
[0009] Moreover, according to the desirable mode of the 1st invention, it is desirable to have a zona-orbicularis ratio modification

member for changing a bore and an outer diameter of the flux of light of the shape of zona orbicularis formed through said flux of light configuration modification member or two or more flux of lights which carried out eccentricity, and leading to said optical integrator. In this case, the 2nd prism member by which said zona-orbicularis ratio modification member has been arranged at a light source means side, Have the 3rd prism member arranged at an irradiated plane side, and a field by the side of an irradiated plane of said 2nd prism member is formed in the shape of [which turned a convex to an irradiated plane side] a cone. A field by the side of a light source means of said 3rd prism member is formed in the shape of [which turned a concave surface to a light source means side] a cone, and, as for either [at least] said 2nd prism member or said 3rd prism members it is desirable to be constituted movable in accordance with said criteria optical axis.

[0010] Furthermore, a field by the side of a light source means of said 2nd prism member is formed in a plane perpendicular to said criteria optical axis in this case, and, as for a field by the side of an irradiated plane of said 3rd prism member, it is desirable to be formed in a plane perpendicular to said criteria optical axis. Moreover, said 2nd prism member is fixed in accordance with said criteria optical axis, and, as for said 3rd prism member, it is desirable to be constituted movable in accordance with said criteria optical axis. Furthermore, as for said light source means, according to the desirable mode of the 1st invention, it is desirable to have a flux of light sensing element for changing the flux of light from the light source and this light source for supplying the rectangle-like flux of light into the flux of light of a circle configuration.

[0011] Moreover, in the 2nd invention of this invention, an aligner characterized by having illumination-light study equipment of the 1st invention and projection optics for carrying out projection exposure of the pattern of a mask arranged on said irradiated plane at a photosensitive substrate is offered. In addition, according to the desirable mode of the 2nd invention, it is desirable to connect with said illumination-light study equipment, and to have further a control means for controlling at least one of said focal distance adjustable optical system, a flux of light configuration modification member, and zona-orbicularis ratio modification members based on information about a pattern of said mask. Furthermore, in the 3rd invention, a mask arranged on said irradiated plane using illumination-light study equipment of the 1st invention is illuminated, and an exposure method characterized by imprinting a pattern of this mask on a photosensitive substrate is offered. In addition, according to the desirable mode of the 3rd invention, it is desirable to control at least one of said focal distance adjustable optical system, a flux of light configuration modification member, and zona-orbicularis ratio modification members based on information about a pattern of said mask.

[0012]

[Embodiment of the Invention] In this invention, the flux of light configuration modification member for changing into two or more flux of lights which carried out eccentricity of the flux of light from the focal distance adjustable optical system and focal distance adjustable optical system for changing the configuration of the flux of light from a light source means in similarity, and injecting it in the optical path between a light source means and an optical integrator to zona-orbicularis-like the flux of light or a criteria optical axis substantially is arranged. Specifically, a flux of light configuration modification member is the cone cone prism or pyramid cone prism constituted free [insertion and detachment] to the illumination-light way. In addition, the field by the side of the light source means of cone cone prism or pyramid cone prism is formed the shape of the shape of a cone, and a pyramid which turned the concave surface to the light source means side, and the field by the side of the irradiated plane is formed the shape of the shape of a cone, and a pyramid which turned the convex to the irradiated plane side. In this case, it is desirable to constitute the field by the side of the light source means of cone cone prism or pyramid cone prism and the field by the side of an irradiated plane in parallel so that it may be maintained, when the inclination to the criteria optical axis of the light which carries out incidence to cone cone prism or pyramid cone prism injects from cone cone prism or pyramid cone prism.

[0013] On the other hand, a light source means has the light source for supplying the flux of light of the shape for example, of a rectangle, and a flux of light sensing element for changing the flux of light from the light source into the flux of light of a circle configuration. Therefore, after the circular flux of light from a light source means minds focal distance adjustable optical system, it is changed into two or more flux of lights which carried out eccentricity to zona-orbicularis-like the flux of light or a criteria optical axis substantially with cone cone prism or pyramid cone prism. It is changed into the flux of light of the shape of a multipole which will become the flux of light of the shape of 8 poles which will become the flux of light of the shape of 4 poles which will consist of the four flux of lights which carried out eccentricity from the criteria optical axis here if the refracting interface of pyramid cone prism is a rectangular-head drill-like from the eight flux of lights which carried out eccentricity from the criteria optical axis if it is 8 pyramids-like from the flux of light of the number according to the number of the sides if it is generally a multiple drill-like. Hereafter, it explains as that in which the 4 pole-like flux of light is formed by pyramid cone prism.

[0014] The flux of light of the shape of the shape of zona orbicularis formed by cone cone prism or pyramid cone prism and 4 poles forms **** of the flux of light of the shape of the shape of zona orbicularis, and 4 poles in the plane of incidence of an optical integrator, consequently forms the secondary zona-orbicularis-like light source or the secondary 4 pole-like light source near the backside [an optical integrator] focal plane. The flux of light from the secondary light source of the shape of the shape of zona orbicularis formed by the optical integrator and 4 poles illuminates an irradiated plane, after being restricted by the aperture diaphragm which has opening (light transmission section) according to the magnitude and the configuration of the secondary light source.

[0015] Thus, in this invention, the secondary light source of the shape of the shape of zona orbicularis and 4 poles can be formed, without almost carrying out quantity of light loss based on the flux of light from a light source means. Consequently, zona-orbicularis deformation lighting and 4 pole deformation lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the flux of light from the secondary light source good. In addition, it cannot be overemphasized evacuating cone cone prism or pyramid cone prism from an illumination-light way, or by replacing with cone cone prism or pyramid cone prism, and positioning a plane-parallel plate all over an illumination-light way that the usual circular lighting can be performed, suppressing quantity of light loss good.

[0016] Moreover, in this invention, the zona-orbicularis ratio can be suitably changed by changing the focal distance of focal distance adjustable optical system, without changing the path of the circular flux of light which carries out incidence to cone cone prism or pyramid cone prism, and changing the bore of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles. Furthermore, the zona-orbicularis ratio can be suitably changed by arranging the axicon (for example, cone convex prism and cone concave prism) of a pair as a zona-orbicularis ratio modification member in the optical path between cone cone prism or pyramid cone prism, and an optical integrator, and changing the gap of the axicon of a pair, without changing the width of face of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles. Therefore, a collaboration operation with focal distance adjustable optical system and the axicon of a pair enables it to set the zona-orbicularis ratio as predetermined magnitude, without changing the outer diameter of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles, to set

the zona-orbicularis ratio as predetermined magnitude, setting the outer diameter of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles as desired magnitude, etc.

[0017] As mentioned above, with the illumination-light study equipment of this invention, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm which restricts the secondary light source good. In addition, the parameter (the magnitude and the configuration of the secondary light source which were restricted) of deformation lighting can be changed by easy actuation of changing the focal distance of focal distance adjustable optical system, suppressing the quantity of light loss by the aperture diaphragm good. Therefore, in the aligner incorporating the illumination-light study equipment of this invention, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions. Moreover, by the exposure method which exposes the pattern of the mask arranged on an irradiated plane using the illumination-light study equipment of this invention on a photosensitive substrate, since projection exposure can be performed under good exposure conditions, a good semiconductor device can be manufactured.

[0018] The example of this invention is explained based on an accompanying drawing. Drawing 1 is drawing showing roughly the configuration of the aligner equipped with the illumination-light study equipment concerning the example of this invention. In drawing 1 , the X-axis is set [the Z-axis] up in the direction perpendicular to the space of drawing 1 for the Y-axis in a wafer side in the direction parallel to the space of drawing 1 in a wafer side along the direction of a normal of the wafer 16 which is a photosensitive substrate, respectively.

[0019] The aligner of drawing 1 is equipped with the excimer laser which supplies wavelength (248nm or 193nm) of light as the light source 1 for supplying exposure light (illumination light). The almost parallel flux of light injected along with the Z direction from the light source 1 has the cross section of the shape of a rectangle prolonged long and slender along the direction of X. Incidence of the flux of light supplied from the light source 1 is carried out to the diffracted-light study element (DOE) 2. The diffracted-light study element 2 is constituted by forming the level difference which has the pitch of the wavelength degree of exposure light (illumination light) in a glass substrate, and has the operation which diffracts an incident beam at a desired angle. Specifically, the diffracted-light study element 2 changes into the flux of light of the circle configuration centering on an optical axis AX the flux of light of the shape of a rectangle which carried out vertical incidence in accordance with the optical axis AX, as shown in drawing 2 . Thus, the diffracted-light study element 2 constitutes the flux of light sensing element for changing the flux of light of the shape of a rectangle from the light source 1 into the flux of light of a circle configuration.

[0020] Incidence of the flux of light changed into the circular cross section through the diffracted-light study element 2 is carried out to a zoom lens 3. Incidence of the flux of light through a zoom lens 3 is carried out to the cone cone prism 4 as the 1st axicon, with a circular cross section maintained. In addition, the path of the circular flux of light which carries out incidence changes to the cone cone prism 4 depending on the focal distance of a zoom lens 3. That is, the zoom lens 3 constitutes the focal distance adjustable optical system for changing the configuration of incoming beams in similarity and injecting it by changing a focal distance. In addition, change of the focal distance of a zoom lens 3 is performed by the 1st mechanical component 22 which operates based on the command from the Maine control section 21.

[0021] The field by the side of the light source (field of the left-hand side in drawing) is formed in the shape of a cone concave surface toward a light source side, and, as for the cone cone prism 4, the field by the side of the mask (field by the side of drawing Nakamigi) is formed in the shape of a cone convex toward the mask side. Furthermore, the refracting interface by the side of the light source of the cone cone prism 4 and the refracting interface by the side of a mask are equivalent to the conical surface (side except a base) of a symmetrical cone about an optical axis AX, and they are constituted by details so that two refracting interfaces may become mutual almost parallel.

[0022] Therefore, after the circular flux of light which carried out incidence to the cone cone prism 4 is deflected along all directions with equiangular centering on an optical axis AX, it is changed into the zona-orbicularis-like (that is, in a circle) flux of light. Thus, the cone cone prism 4 constitutes the flux of light configuration modification member for changing the flux of light of a circle configuration into the zona-orbicularis-like flux of light. In addition, to the illumination-light way, it is constituted free [insertion and detachment], and the cone cone prism 4 is constituted possible [plane-parallel-plate 4a, pyramid cone prism 4b, and a switch]. Evacuation from a switch and illumination-light way of the cone cone prism 4, and plane-parallel-plate 4a and pyramid cone prism 4b is performed by the 2nd mechanical component 23 which operates based on the command from the Maine control section 21.

[0023] In addition, although pyramid cone prism 4b has a configuration similar to the cone cone prism 4, by pyramid cone prism 4b, the refracting interface of a pair is formed in the shape of a rectangular-head drill to the refracting interface of a pair being formed in the shape of a cone by the cone cone prism 4. That is, the refracting interface by the side of the light source of pyramid cone prism 4b and the refracting interface by the side of a mask are equivalent to the pyramidal surface (side except a base) of a symmetrical positive rectangular-head drill about an optical axis AX, and they are constituted so that two refracting interfaces may become mutual almost parallel.

[0024] Incidence of the flux of light changed in the shape of zona orbicularis through the cone cone prism 4 is carried out to the cone convex prism 5 as the 2nd axicon, and the cone concave prism 6 as the 3rd axicon. The cone convex prism 5 is formed in a plane with the field perpendicular to an optical axis AX by the side of the light source, and the field by the side of the mask is formed in the shape of a cone convex toward the mask side. On the other hand, the field by the side of the light source is formed in the shape of a cone concave surface toward a light source side, and the cone concave prism 6 is formed in the plane with the field perpendicular to an optical axis AX by the side of the mask. And the refracting interface by the side of the mask of the cone convex prism 5 and the refracting interface by the side of the light source of the cone concave prism 6 are equivalent to the conical surface of a symmetrical cone about an optical axis AX, and they are constituted so that two refracting interfaces which counter may contact substantially in the condition of having made it approaching mutually.

[0025] Moreover, it is constituted so that the cone convex prism 5 may be immobilization in accordance with an optical axis AX and may move the cone concave prism 6 in accordance with an optical axis AX. If it puts in another way, it is constituted so that the gas gap of the cone convex prism 5 and the cone concave prism 6 can be changed. In this case, migration in alignment with the optical axis AX of the cone concave prism 6 is performed by the 3rd mechanical component 24 which operates based on the command from the Maine control section 21. In addition, about the operation when changing the gas gap of the cone convex prism 5 and the cone concave prism 6, it relates with an operation of a zoom lens 3 and the cone cone prism 4, and mentions later. Although it is injected while the flux of light of the shape of zona orbicularis which carried out incidence to the axicons 5 and 6 of a pair had kept the zona-

orbicularis-like cross section general, the bore and outer diameter change depending on the gas gap of the cone convex prism 5 and the cone concave prism 6.

[0026] After the flux of light of the shape of zona orbicularis through the cone convex prism 5 and the cone concave prism 6 minds a relay lens 7, incidence of it is carried out to the fly eye lens 8 as an optical integrator. In this way, **** of the shape of zona orbicularis centering on an optical axis AX is formed in the plane of incidence of the fly eye lens 8. The fly eye lens 8 is constituted by carrying out the in-every-direction array of the lens element of a large number which have positive refractive power in accordance with an optical axis AX. And each lens element which constitutes the fly eye lens 8 has the cross section of the shape of a rectangle [**** / the configuration (as a result, configuration of the exposure field which should be formed on a wafer) of **** which should be formed on a mask].

[0027] The flux of light which carried out incidence to the fly eye lens 8 is divided by many lens elements two-dimensional, and a light source image is formed in a backside [each lens element in which the flux of light carried out incidence] focal plane, respectively. In this way, the light source (henceforth the "secondary light source") of the shape of same zona orbicularis as **** formed of the incoming beams to the fly eye lens 8 is formed in a backside [the fly eye lens 8] focal plane. Incidence of the flux of light from the secondary light source of the shape of zona orbicularis formed in the backside [the fly eye lens 8] focal plane is carried out to the aperture diaphragm 9 arranged in the near. This aperture diaphragm 9 is supported on the turret substrate (rotor plate) 10 pivotable to the circumference of a predetermined axis parallel to an optical axis AX.

[0028] Drawing 3 is drawing showing roughly the configuration of the turret by which two or more aperture diaphragms have been arranged in the shape of the circumference. As shown in drawing 3 , eight aperture diaphragms which have the light transmission region shown in the turret substrate 10 with the slash in drawing are prepared along with the circumferencial direction. The turret substrate 10 is constituted pivotable through the central point O at the circumference of an axis parallel to an optical axis AX. Therefore, one aperture diaphragm chosen from eight aperture diaphragms can be positioned all over an illumination-light way by rotating the turret substrate 10. In addition, rotation of the turret substrate 10 is performed by the 4th mechanical component 25 which operates based on the command from the Maine control section 21.

[0029] Three zona-orbicularis aperture diaphragms 401, 403, and 405 from which a zona-orbicularis ratio differs are formed in the turret substrate 10. Here, the zona-orbicularis aperture diaphragm 401 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r11/r21. The zona-orbicularis aperture diaphragm 403 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r12/r22. The zona-orbicularis aperture diaphragm 405 has the transparency field of the shape of zona orbicularis which has the zona-orbicularis ratio of r13/r21.

[0030] Moreover, three 4 pole aperture diaphragms 402, 404, and 406 from which a zona-orbicularis ratio differs are formed in the turret substrate 10. Here, 4 pole aperture diaphragm 402 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r11/r21. 4 pole aperture diaphragm 404 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r12/r22. 4 pole aperture diaphragm 406 has four circular transparency fields which carried out eccentricity in the zona-orbicularis-like field which has the zona-orbicularis ratio of r13/r21. Furthermore, two circular aperture diaphragms 407 and 408 from which magnitude (aperture) differs are formed in the turret substrate 10. Here, the circular aperture diaphragm 407 has the circular transparency field of the magnitude of two r22, and the circular aperture diaphragm 408 has the circular transparency field of the magnitude of two r21.

[0031] Therefore, by choosing zona-orbicularis 1 of three zona-orbicularis aperture diaphragms 401, 403, and 405, and positioning in an illumination-light way, the zona-orbicularis flux of light which has three different zona-orbicularis ratios can be restricted correctly (convention), and three kinds of zona-orbicularis deformation lighting with which zona-orbicularis ratios differ can be performed. Moreover, by choosing 4 pole 1 of three 4 pole aperture diaphragms 402, 404, and 406, and positioning in an illumination-light way, the four eccentric flux of lights which have three different zona-orbicularis ratios can be restricted correctly, and three kinds of 4 pole deformation lighting with which zona-orbicularis ratios differ can be performed. Furthermore, two kinds of usual circular lighting with which sigma values differ can be performed by choosing circular 1 of two circular aperture diaphragms 407 and 408, and positioning in an illumination-light way.

[0032] In drawing 1 , since the secondary zona-orbicularis-like light source is formed in a backside [the fly eye lens 8] focal plane, one zona-orbicularis aperture diaphragm chosen from three zona-orbicularis aperture diaphragms 401, 403, and 405 as an aperture diaphragm 9 is used. However, the class and number of aperture diaphragms which are instantiation-like [the configuration of a turret shown in drawing 3], and are arranged are not limited to this. Moreover, the possible aperture diaphragm of changing light transmission area size and a configuration suitably may be attached fixed in an illumination-light way, without being limited to the aperture diaphragm of a turret method. Furthermore, it can replace with two circular aperture diaphragms 407 and 408, and the tris diaphragm to which the diameter of a circular opening can be changed continuously can also be prepared.

[0033] An aperture diaphragm 9 is arranged in the entrance pupil side of the projection optics 15 mentioned later, and a location [**** / optical almost], and specifies the range of the secondary light source which contributes to lighting. The light from the secondary light source through the aperture diaphragm 9 which has a zona-orbicularis-like opening (light transmission section) carries out incidence of the condensing operation of a condenser lens 11 to the mask blind 12 after a carrier beam. The mask blind 12 is a field diaphragm arranged in the mask 14 and the location [**** / optical almost], in order to specify the lighting field of the mask 14 mentioned later. The flux of light through the mask blind 12 illuminates in superposition the mask 14 with which the predetermined imprint pattern was formed through the image formation optical system 13.

[0034] The flux of light which penetrated the pattern of a mask 14 forms the image of a mask pattern through projection optics 15 on the wafer 16 which is a photosensitive substrate. here, since the aperture diaphragm 9 and the entrance pupil side of projection optics 15 are mostly arranged conjugate as mentioned above, the image of the secondary light source forms on the entrance pupil side of projection optics 15 — having — a mask 14 and a wafer 16 — being the so-called — Koehler illumination is carried out. In the entrance pupil side of projection optics 15, aperture-diaphragm 15a adjustable in the aperture for restricting the flux of light from the image of the secondary light source is arranged. Change of the aperture of this aperture-diaphragm 15a is performed by the 5th mechanical component 26 which operates based on the command from the Maine control section 21. In this way, the pattern of a mask 14 is serially exposed by each exposure field of a wafer 16 by performing one-shot exposure or scanning exposure, carrying out drive control of the wafer 16 two-dimensional into the plane (XY plane) which intersects perpendicularly with the optical axis AX of projection optics 15.

[0035] Drawing 4 is drawing which explains that a change for lighting can usually be performed with deformation lighting by the insertion and detachment to the illumination-light way of the cone cone prism 4 or pyramid cone prism 4b. As shown in drawing 4 (a),

in the condition which contacted without the cone convex prism 5 and the cone concave prism 6 separating a gap, or the condition of having approached very much, without separating a gap substantially, the cone prism 5 and 6 of a pair is united, and functions as a plane-parallel plate. Therefore, the flux of light of the shape of zona orbicularis formed through the cone cone prism 4 penetrates the cone prism 5 and 6 of a pair as it is, forms zona-orbicularis-like **** in the plane of incidence of the fly eye lens 8, and forms the secondary zona-orbicularis-like light source in an after that side focal plane.

[0036] In addition, when it replaces with the cone cone prism 4 and pyramid cone prism 4b is positioned all over an illumination-light way, the 4 pole-like flux of light is formed through pyramid cone prism 4b, 4 pole-like **** is formed in the plane of incidence of the fly eye lens 8, and the secondary 4 pole-like light source is formed in an after that side focal plane. Here, the 4 pole-like flux of light consists of the four flux of lights which carried out eccentricity symmetrically to the optical axis AX, and the secondary 4 pole-like light source consists of the four light sources which carried out eccentricity symmetrically to the optical axis AX. Thus, by positioning the cone cone prism 4 all over an illumination-light way, zona-orbicularis deformation lighting can be realized and 4 pole deformation lighting can be realized by positioning pyramid cone prism 4b all over an illumination-light way.

[0037] On the other hand, if the cone cone prism 4 or pyramid cone prism 4b is evacuated from the condition of drawing 4 (a) as shown in drawing 4 (b), incidence of the circular flux of light through a zoom lens 3 will be carried out to the cone prism 5 and 6 of a pair, without being changed into the zona-orbicularis-like flux of light or the 4 pole-like flux of light. Consequently, the flux of light which penetrated the cone prism 5 and 6 of a pair as it was forms circular **** in the plane of incidence of the fly eye lens 8, and forms the circular secondary light source near the after that side focal plane. Furthermore, if the path of circular **** formed in the plane of incidence of the fly eye lens 8 if the focal distance of a zoom lens 3 is changed from the condition of drawing 4 (b) and the path of the circular flux of light which carries out incidence to the cone prism 5 and 6 of a pair will pull pulls as shown in drawing 4 (c), the path of the circular secondary light source changes.

[0038] As mentioned above, the insertion and detachment to the illumination-light way of the cone cone prism 4 or pyramid cone prism 4b can usually perform a change for lighting with deformation lighting (namely, zona-orbicularis lighting or 4 pole lighting). In this case, plane-parallel-plate 4a which has predetermined shaft top thickness may be inserted in an illumination-light way instead of the cone cone prism 4 or pyramid cone prism 4b so that the optical path length may not change the insertion-and-detachment front of the cone cone prism 4 or pyramid cone prism 4b, and after insertion and detachment. Moreover, the condition to which the cone cone prism 4 or pyramid cone prism 4b was evacuated from the illumination-light way, or where plane-parallel-plate 4a is positioned all over an illumination-light way, the path of the circular flux of light in lighting can usually be changed by changing the focal distance of a zoom lens 3.

[0039] Drawing 5 is drawing explaining an operation of the zoom lens 3 in zona-orbicularis lighting or 4 pole lighting. As shown in drawing 5 (a), in the condition which the cone convex prism 5 and the cone concave prism 6 contacted, or the condition of having approached very much, the flux of light of the shape of zona orbicularis formed through the cone cone prism 4 penetrates the cone prism 5 and 6 of a pair as it is. In this case, it depends for the bore d1 of the flux of light of the shape of zona orbicularis through the cone prism 5 and 6 of a pair on the vertical angle of the cone cone prism 4, that shaft top thickness, and its refractive index. Moreover, it depends for the outer diameter d2 of the zona-orbicularis-like flux of light not only on the vertical angle of the cone cone prism 4, the shaft top thickness, and its refractive index but on the path d0 of the circular flux of light which carries out incidence to the cone cone prism 4.

[0040] On the other hand, if the focal distance of a zoom lens 3 is changed from the condition of drawing 5 (a) as shown in drawing 5 (b), the path of the circular flux of light which carries out incidence will change to the cone cone prism 4. Consequently, although the bore d1 of the flux of light of the shape of zona orbicularis through the cone prism 5 and 6 of a pair does not change, the outer diameter d2 changes depending on change of the path d0 of the circular flux of light. In addition, since the path d0 of the circular flux of light which carries out incidence to pyramid cone prism 4b will change if the focal distance of a zoom lens 3 is changed similarly also when it replaces with the cone cone prism 4 and pyramid cone prism 4b is positioned all over an illumination-light way Although the bore d1 of the flux of light of the shape of 4 poles through the cone prism 5 and 6 of a pair does not change, the outer diameter d2 changes depending on change of the path d0 of the circular flux of light.

[0041] Here, the bore of the 4 pole-like flux of light and an outer diameter are the bores and outer diameters of the zona-orbicularis-like field which the 4 pole-like flux of light occupies. Therefore, the zona-orbicularis ratio of the 4 pole-like flux of light is defined as a bore/an outer diameter like the zona-orbicularis ratio of the zona-orbicularis-like flux of light. As mentioned above, the zona-orbicularis ratio and outer diameter can be changed [both], without changing the bore of the flux of light in zona-orbicularis lighting or 4 pole lighting by changing the focal distance of a zoom lens 3 in the condition or the condition of having approached very much which the cone convex prism 5 and the cone concave prism 6 contacted.

[0042] Drawing 6 is drawing explaining an operation of the cone prism 5 and 6 of the pair in zona-orbicularis lighting or 4 pole lighting, and an operation of a zoom lens 3. As shown in drawing 6 (a), the flux of light of the shape of zona orbicularis in which the cone convex prism 5 and the cone concave prism 6 were formed in contact or the condition of having approached very much, through the cone cone prism 4 or pyramid cone prism 4b, or the 4 pole-like flux of light penetrates the cone prism 5 and 6 of a pair as it is. Consequently, **** of the shape of the shape of zona orbicularis and 4 poles is formed in the plane of incidence of the fly eye lens 8, and the secondary light source of the shape of the shape of zona orbicularis and 4 poles is formed near the after that side focal plane.

[0043] On the other hand, if the cone concave prism 6 is moved to a mask side from the condition of drawing 6 (a) as shown in drawing 6 (b) Although the width of face d3 (d3= (d2-d1)/2) of the flux of light of the shape of zona orbicularis through the cone prism 5 and 6 of a pair or the 4 pole-like flux of light does not change, the bore d1 becomes small depending on the gas gap of the cone convex prism 5 and the cone concave prism 6. Consequently, the outer diameter d2 of the zona-orbicularis-like flux of light or the 4 pole-like flux of light as well as the bore d1 becomes small depending on the gas gap of the cone convex prism 5 and the cone concave prism 6.

[0044] Moreover, if the focal distance of a zoom lens 3 is changed from drawing 6 (a) as shown in drawing 6 (c), the path d0 of the circular flux of light which carries out incidence to the cone cone prism 4 or pyramid cone prism 4b will change. Consequently, although the bore d1 of the flux of light of the shape of zona orbicularis through the cone prism 5 and 6 of a pair or the 4 pole-like flux of light does not change, the outer diameter d2 changes depending on change of the path of the circular flux of light, and the width of face d3 of the zona-orbicularis-like flux of light or the 4 pole-like flux of light also changes in connection with it.

[0045] Furthermore, if the cone concave prism 6 is moved to a mask side from drawing 6 (c) as shown in drawing 6 (d), although the width of face d3 of the flux of light of the shape of zona orbicularis through the cone prism of a pair and 6 or the 4 pole-like flux of light does not change, the bore d1 will become small depending on the gas gap of the cone convex prism 5 and the cone concave

prism 6. Consequently, the outer diameter d2 of the zona-orbicularis-like flux of light or the 4 pole-like flux of light as well as the bore d1 becomes small depending on the gas gap of the cone convex prism 5 and the cone concave prism 6.

[0046] As mentioned above, the bore and outer diameter can be changed [both], without changing the width of face of the flux of light in zona-orbicularis lighting or 4 pole lighting by changing the gas gap of the cone convex prism 5 and the cone concave prism 6. Moreover, while changing the gas gap of the cone convex prism 5 and the cone concave prism 6, the width of face, bore, and outer diameter of the flux of light in zona-orbicularis lighting or 4 pole lighting can be changed by changing the focal distance of a zoom lens 3, respectively. If it puts in another way, a zona-orbicularis ratio can be changed to desired magnitude by changing suitably the gas gap of the cone convex prism 5 and the cone concave prism 6, and the focal distance of a zoom lens 3, respectively, changing a zona-orbicularis ratio to desired magnitude, or making it change to the magnitude of a request of an outer diameter without changing an outer diameter in zona-orbicularis lighting or 4 pole lighting.

[0047] Drawing 7 is drawing explaining how to usually illuminate according to a collaboration operation with the cone prism 5 and 6 of a pair, and a zoom lens 3, without evacuating the cone cone prism 4 from an illumination-light way. As shown in drawing 7 (a), the flux of light of the shape of zona orbicularis in which the cone convex prism 5 and the cone concave prism 6 were formed through the cone cone prism 4 in contact or the condition of having approached very much penetrates the cone prism 5 and 6 of a pair as it is, and forms zona-orbicularis-like **** in the plane of incidence of the fly eye lens 8.

[0048] On the other hand, if the cone concave prism 6 is gradually moved to a mask side from the condition of drawing 7 (a) as shown in drawing 7 (b), the bore d1 of the flux of light of the shape of zona orbicularis through the cone prism 5 and 6 of a pair becomes small gradually, and a bore d1 will be in the condition of 0 soon. That is, the cross-section configuration of the flux of light through the cone prism 5 and 6 of a pair becomes circular, and lighting can usually be attained.

[0049] Furthermore, if the focal distance of a zoom lens 3 is changed without moving the cone concave prism 6 from the condition of drawing 7 (b) as shown in drawing 7 (c), the path of the circular flux of light which the path d0 of the circular flux of light which carries out incidence changes to the cone cone prism 4, consequently is formed through the cone prism 5 and 6 of a pair will change. As mentioned above, in lighting, the path of the circular flux of light can usually be changed to desired magnitude by changing the focal distance of a zoom lens 3 suitably, where the gas gap of the cone convex prism 5 and the cone concave prism 6 is set as predetermined magnitude.

[0050] Hereafter, switch actuation of the flux of light configuration modification member in this example and an aperture diaphragm etc. is explained concretely. First, the information about various kinds of masks which should carry out sequential exposure according to step-and-repeat method or step - and - scanning method etc. is inputted into the Maine control section 21 through the input sections 20 (a console, a bar code reader, keyboard, etc.). The Maine control section 21 has memorized information, such as optimal line breadth (resolution) about various kinds of masks, and the depth of focus, in the internal memory section, answers an input from the input section 20, and supplies the suitable control signal for the 1st mechanical component 22 - the 5th mechanical component 26.

[0051] That is, when performing zona-orbicularis deformation lighting or 4 pole deformation lighting under the optimal resolution and the depth of focus, the 2nd mechanical component 23 positions the cone cone prism 4 or pyramid cone prism 4a all over an illumination-light way based on the command from the Maine control section 21. And in order to acquire the secondary light source of the shape of the shape of zona orbicularis which has a desired outer diameter and a desired zona-orbicularis ratio [near the backside / the fly eye lens 8 / focal plane], and 4 poles The 1st mechanical component 22 sets the focal distance of a zoom lens 3 as predetermined magnitude based on the command from the Maine control section 21, and the 3rd mechanical component 24 sets the gas gap of the cone convex prism 5 and the cone concave prism 6 as predetermined magnitude based on the command from the Maine control section 21.

[0052] Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary light source of the shape of the shape of zona orbicularis, and 4 poles, the 4th mechanical component 25 rotates the turret substrate 10 based on the command from the Maine control section 21, and positions a desired zona-orbicularis aperture diaphragm or desired 4 pole aperture diaphragm all over an illumination-light way. Furthermore, the 5th mechanical component 26 sets the variable aperture of aperture-diaphragm 15a as desired magnitude based on the command from the Maine control section 21. In this way, the secondary light source of the shape of the shape of zona orbicularis and 4 poles can be formed without almost carrying out quantity of light loss based on the flux of light from the light source 1, and zona-orbicularis deformation lighting or 4 pole deformation lighting can be performed, without almost carrying out quantity of light loss in the aperture diaphragm which, as a result, restricts the flux of light from the secondary light source.

[0053] Furthermore, the outer diameter and zona-orbicularis ratio of the secondary light source of the shape of the shape of zona orbicularis formed near the backside [the fly eye lens 8] focal plane and 4 poles can be suitably changed if needed by changing the focal distance of a zoom lens 3 by the 1st mechanical component 22, or changing the gas gap of the cone convex prism 5 and the cone concave prism 6 by the 3rd mechanical component 24. In this case, the turret substrate 10 rotates according to change of the outer diameter of the secondary light source of the shape of the shape of zona orbicularis, and 4 poles, and a zona-orbicularis ratio, the zona-orbicularis aperture diaphragm or 4 pole aperture diaphragm which has a desired outer diameter and a desired zona-orbicularis ratio is chosen, and it is positioned all over an illumination-light way. Moreover, the 5th mechanical component 26 changes the variable aperture of aperture-diaphragm 15a based on the command from the Maine control section 21. In this way, without almost carrying out quantity of light loss in formation and its limit of the shape of the shape of zona orbicularis, and 4 poles of the secondary light source, the outer diameter and zona-orbicularis ratio of the secondary light source of the shape of the shape of zona orbicularis and 4 poles can be changed suitably, and various zona-orbicularis deformation lighting or 4 pole deformation lighting can be performed.

[0054] On the other hand, when carrying out the circular lighting usual by the basis of the optimal resolution and the depth of focus, the 2nd mechanical component 23 evacuates the cone cone prism 4 or pyramid cone prism 4b from an illumination-light way based on the command from the Maine control section 21, and positions plane-parallel-plate 4a in an illumination-light way if needed. And in order to acquire the secondary light source of the circle configuration which has a desired outer diameter [near the backside / the fly eye lens 8 / focal plane], the 1st mechanical component 22 sets the focal distance of a zoom lens 3 as predetermined magnitude based on the command from the Maine control section 21. Or while the 3rd mechanical component 24 sets the gas gap of the cone convex prism 5 and the cone concave prism 6 as predetermined magnitude based on the command from the Maine control section 21, positioning the cone cone prism 4 in an illumination-light way, the 1st mechanical component 22 sets the focal distance of a zoom lens 3 as predetermined magnitude based on the command from the Maine control section 21.

[0055] Moreover, where quantity of light loss is suppressed good, in order to restrict the secondary light source of a circle

configuration, the 4th mechanical component 25 rotates the turret substrate 10 based on the command from the Maine control section 21, and positions a desired circular aperture diaphragm all over an illumination-light way. Furthermore, the 5th mechanical component 26 sets the variable aperture of aperture-diaphragm 15a as desired magnitude based on the command from the Maine control section 21. In this way, circular lighting can usually be performed, suppressing quantity of light loss good in the aperture diaphragm which restricts the flux of light from the formed secondary light source without almost carrying out quantity of light loss based on the flux of light from the light source 1.

[0056] Furthermore, the outer diameter of the secondary light source of the circle configuration formed near the backside [the fly eye lens 8] focal plane can be suitably changed if needed by changing the focal distance of a zoom lens 3 by the 1st mechanical component 22. In this case, the turret substrate 10 rotates according to change of the outer diameter of the secondary light source of a circle configuration, the circular aperture diaphragm which has opening of a desired outer diameter is chosen, and it is positioned all over an illumination-light way. Moreover, the 5th mechanical component 26 changes the variable aperture of aperture-diaphragm 15a based on the command from the Maine control section 21. In this way, suppressing quantity of light loss good in formation and its limit of a circle configuration of the secondary light source, a sigma value can be changed suitably and various usual circular lighting can be performed.

[0057] As mentioned above, in the above-mentioned example, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm for restricting the secondary light source good. In addition, the parameter of circular lighting and deformation lighting can usually be continuously changed by easy actuation of changing the focal distance of a zoom lens or changing the gas gap of the cone prism (axicon of a pair) of a pair, suppressing the quantity of light loss by the aperture diaphragm good. Therefore, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions.

[0058] Since the wafer which passed through the production process (photolithography production process) of exposure by the aligner of an above-mentioned example should pass the production process to develop, a wafer process ends it through the production process of resist removal of removing the unnecessary resist after the production process of etching of removing portions other than the developed resist, and the production process of etching etc. And finally termination of a wafer process manufactures the semiconductor devices (LSI etc.) as a device like an actual erector through each production process, such as dicing which was able to be burned and which cuts and chip-izes a wafer for every circuit, bonding which gives wiring etc. to each chip, and packaging which carries out packaging for every chip.

[0059] In addition, although the above explanation showed the example which manufactures a semiconductor device according to the photolithography production process in the wafer process which used the projection aligner, a liquid crystal display element, the thin film magnetic head, and image sensors (CCD etc.) can be manufactured as a semiconductor device according to the photolithography production process using an aligner. In this way, since projection exposure can be performed under good exposure conditions in the case of the exposure method of manufacturing a semiconductor device using the illumination-light study equipment of this invention, a good semiconductor device can be manufactured.

[0060] In addition, in an above-mentioned example, it can constitute so that a plane-parallel plate may be positioned all over an illumination-light way for example, by the turret method in the cone cone prism as the 1st axicon, and a pyramid cone prism list. Moreover, insertion and detachment and a change of an above-mentioned prism member and a plane-parallel plate can also be performed, for example using a well-known slider style. Moreover, although the cone convex prism as the 2nd axicon is considered as immobilization and the cone concave prism as the 3rd axicon is made movable in the above-mentioned example, cone convex prism is made movable, cone concave prism can be considered as immobilization, or both cone prism can also be made movable. However, since it becomes layout top difficulty to secure the successive range of cone convex prism in many cases, it is desirable to consider cone convex prism as immobilization, and to carry out movable [of the cone concave prism], as shown in an example.

[0061] Furthermore, in the above-mentioned example, although positive rectangular-head drill cone prism is used as pyramid cone prism, positive 8 pyramid cone prism and common multiple drill cone prism can also be used if needed. Moreover, in the above-mentioned example, although the fly eye lens is used as an optical integrator, the optical integrator (namely, rod mold integrator) of a rod mold can also be used, for example. In addition, a rod mold integrator is the glass rod of the internal reflection mold which consists of a glass material like quartz glass or fluorite, and forms the light source image of the number according to the number of internal reflection along a field parallel to rod plane of incidence through a condensing point using total reflection, the interface, i.e., the inside, of the interior and the exterior. Here, although most light source images formed are images, only a central (condensing point) light source image turns into a real image. That is, the flux of light which carried out incidence to the rod mold integrator is divided in the angle direction by internal reflection, and the secondary light source which consists of many light source images along a field parallel to the plane of incidence through a condensing point is formed.

[0062] Furthermore, in the above-mentioned example, although the diffracted-light study element is used as a flux of light sensing element, a dioptrics element like a micro-lens array or micro-lens prism can also be used, for example, without being limited to this. In addition, a flux of light sensing element can omit arrangement of a flux of light sensing element not in a component indispensable to this invention but in an above-mentioned example, and can carry out incidence of the rectangle-like flux of light to the 1st axicon. Moreover, although the rectangle-like flux of light is changed into the circular flux of light by the diffracted-light study element as a flux of light sensing element, it can also constitute from an above-mentioned example so that the rectangle-like flux of light may be changed into the 4 pole-like flux of light, for example.

[0063] Furthermore, in the above-mentioned example, the aperture diaphragm for restricting the flux of light of the secondary light source is arranged near the backside [a fly eye lens] focal plane. However, the configuration which omits arrangement of an aperture diaphragm and does not restrict the flux of light of the secondary light source at all is also possible by setting up sufficiently small the cross section of each lens element which constitutes a fly eye lens depending on the case. Moreover, although the axicon of a pair is arranged in the optical path between the 1st axicon and an optical integrator in the above-mentioned example, the axicon of this pair is not a component indispensable to this invention. Furthermore, various modifications are possible, without also limiting the configuration of the axicon of a pair to an above-mentioned example. For example, when the cone cone prism 4 is exchanged for pyramid cone prism 4b, the pair of the cone axicons 5 and 6 may be exchanged for the pair of the pyramid axicons 5b and 6b.

[0064] Moreover, although the above-mentioned example explained this invention taking the case of the projection aligner equipped with illumination-light study equipment, it is clear that this invention is applicable to the common illumination-light study equipment

for carrying out homogeneity lighting of the irradiated planes other than a mask. Furthermore, although the above example showed the example using the ArF excimer laser which supplies the KrF excimer laser and the 193nm wavelength light which supply 248nm wavelength light as the light source, it cannot be overemphasized that this invention is applicable also to equipment equipped with the light sources other than this. For example, F2 which supplies 157nm wavelength light It is also possible to use the light source unit which consists of combination of laser light sources, such as laser, or the laser light source which supplies the light of predetermined wavelength, and the nonlinear optical element which changes the light from the laser light source into light with a short wavelength of 200nm or less etc. as a light source means of this invention.
[0065]
[Effect of the Invention] As explained above, with the illumination-light study equipment of this invention, deformation lighting like zona-orbicularis deformation lighting or 4 pole deformation lighting and usual circular lighting can be performed, suppressing the quantity of light loss in the aperture diaphragm for restricting the secondary light source good. In addition, the parameter of deformation lighting can be changed by easy actuation of changing the focal distance of a zoom lens or changing the gas gap of the axicon of a pair, suppressing the quantity of light loss by the aperture diaphragm good.
[0066] Therefore, in the aligner incorporating the illumination-light study equipment of this invention, the class and parameter of deformation lighting can be changed suitably, and the resolution and the depth of focus of projection optics suitable for the detailed pattern which should carry out exposure projection can be obtained. Consequently, good high projection exposure of a throughput can be performed under a high exposure illuminance and good exposure conditions. Moreover, by the exposure method which exposes the pattern of the mask arranged on an irradiated plane using the illumination-light study equipment of this invention on a photosensitive substrate, since projection exposure can be performed under good exposure conditions, a good semiconductor device can be manufactured.

[Translation done.]

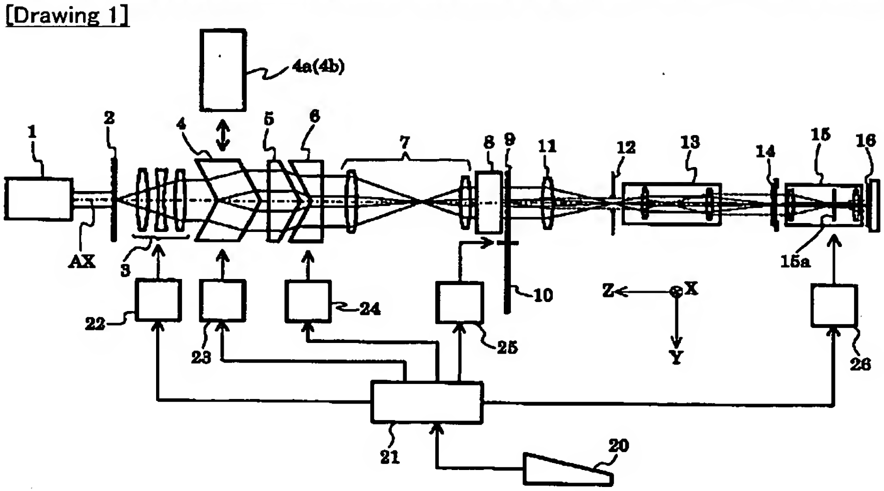
* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

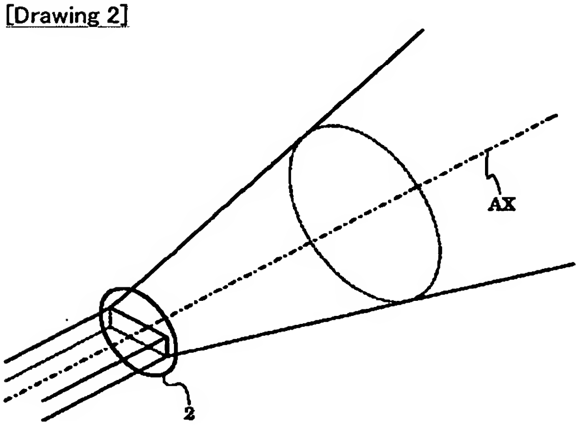
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

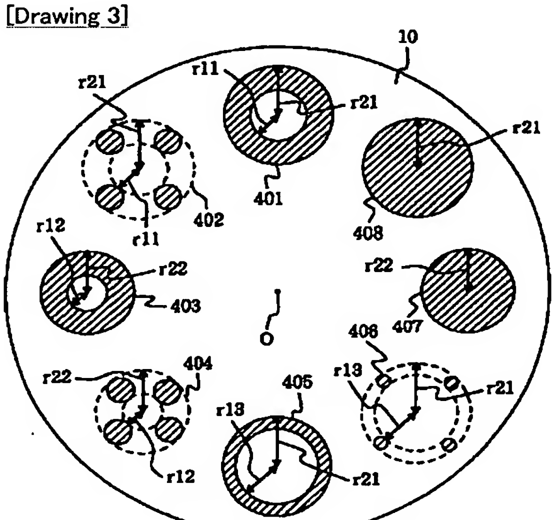
[Drawing 1]



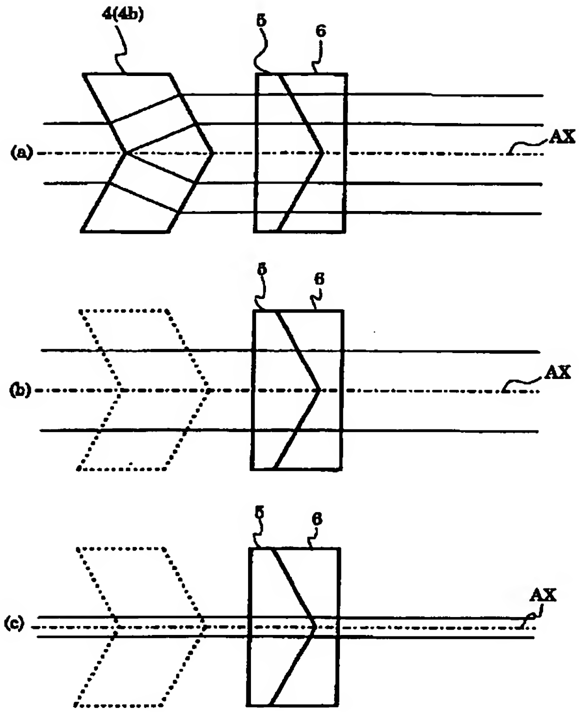
[Drawing 2]



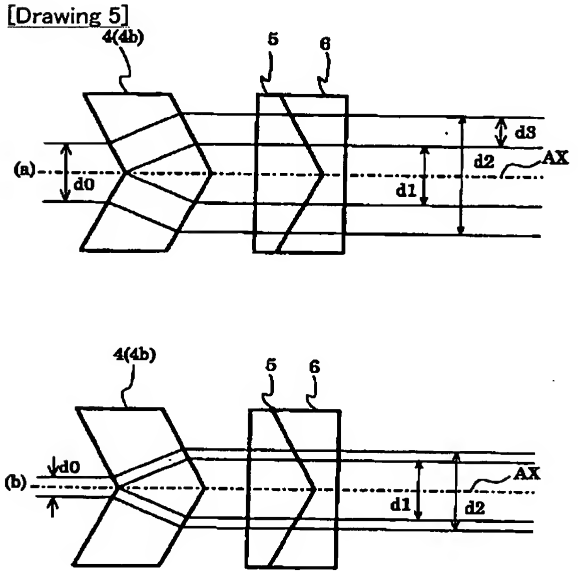
[Drawing 3]



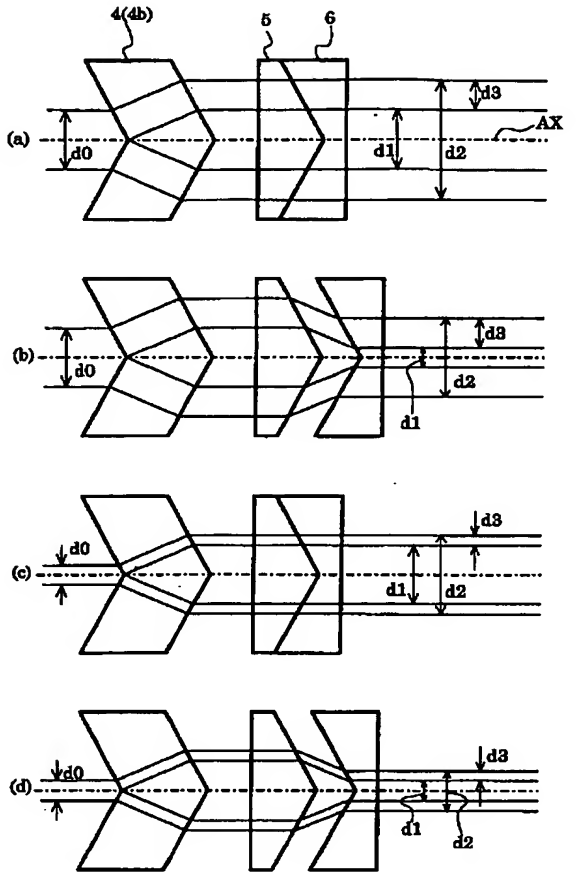
[Drawing 4]



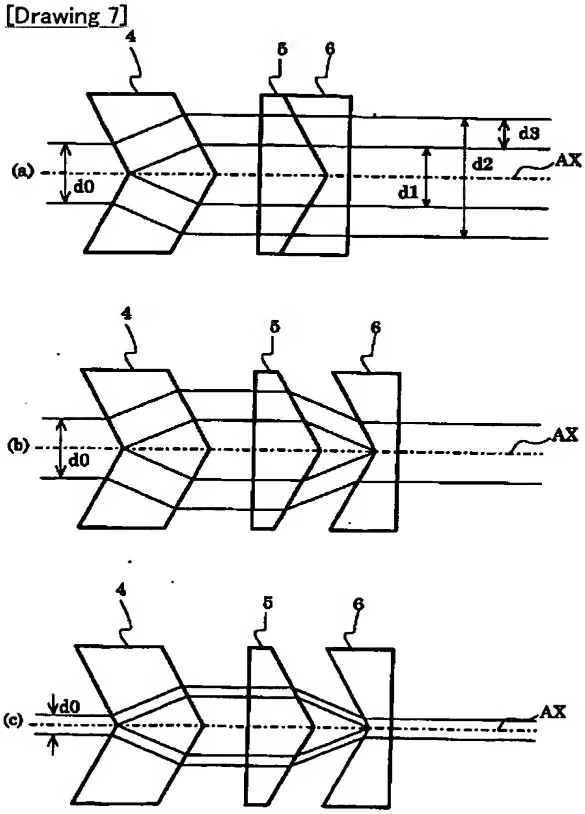
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]